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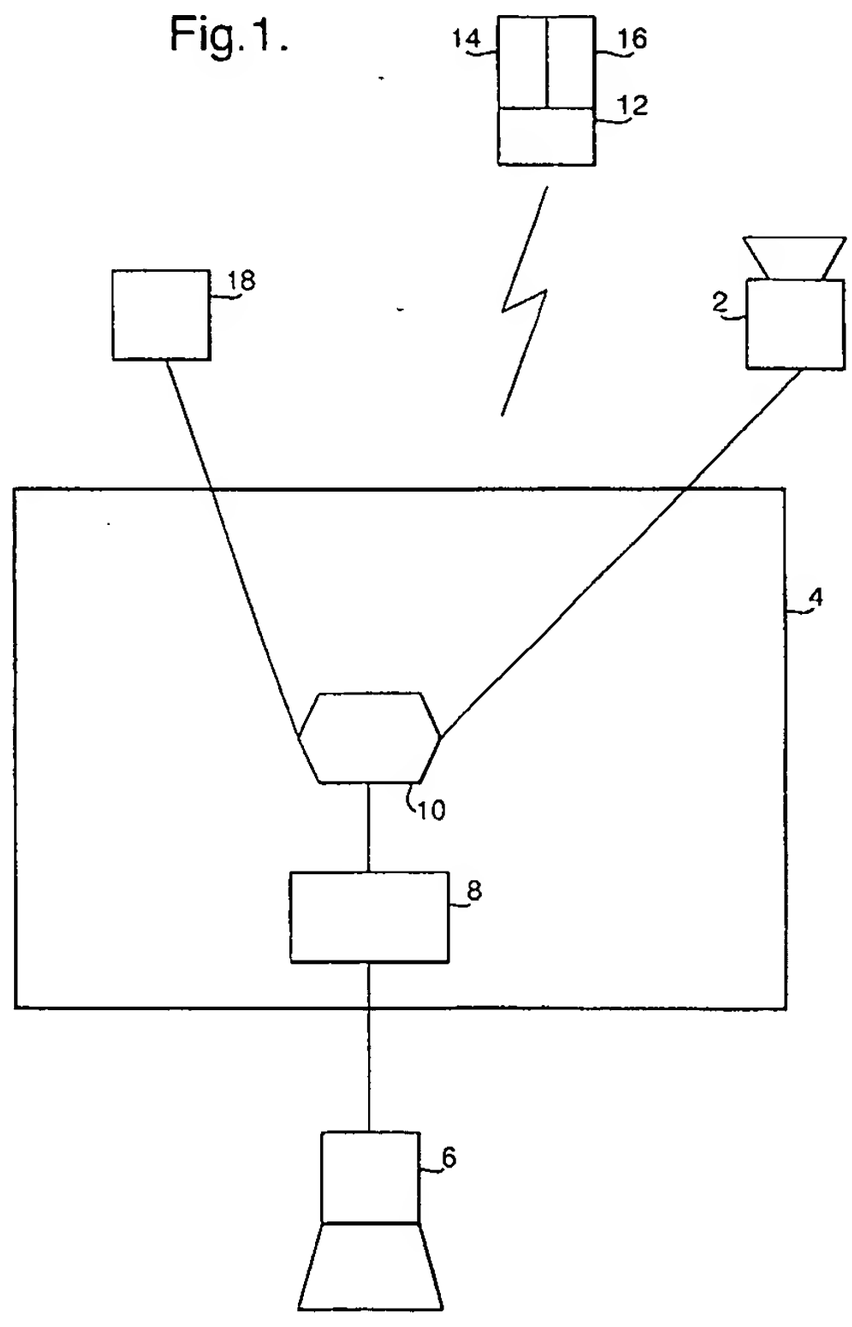
(54) An IC chip for a hearing aid, a hearing aid and a system for adjusting a hearing aid

(57) The present invention relates to a hearing aid which enables the hearing aid to be adjusted by the user independently. The hearing aid comprises a microphone for receiving audio signals; processing means coupled to the microphone; and a receiver coupled to the processing means for outputting optimum audio signals; whereby said processing means includes means for activating test sounds and a processor arranged to receive result data according to a users ability to hear said test sounds to calculate and adjust the gain calibration for optimising the hearing aid for the user. The system also includes an input means for activating the test procedure and for providing detection data as to whether the user can detect sounds in the test procedure.

Fig.1.



EP 1 261 235 A2

Description

[0001] The present invention relates to an IC chip for a hearing aid, a hearing aid and a system for adjusting a hearing aid and in particular a hearing aid and a system for adjusting a hearing aid whereby a user is able to adjust independently the hearing aid.

[0002] Hitherto, hearing aids have been worn by users with hearing dysfunction. A hearing aid acts by adjusting the gain at the frequencies at which the user has hearing dysfunction.

[0003] The hearing aid may be either analogue or digital. Typically, a hearing aid comprises a microphone, hearing rehabilitator, and a receiver. The microphone receives sounds, the hearing rehabilitator adjusts the gain at the frequencies at which the user has hearing dysfunction and the receiver outputs the corrected sound for the user.

[0004] A hearing aid is calibrated to adjust the gain to suit each user. A hearing aid fitting is usually required and conducted by an audiologist or other trained professional. The audiologist calibrates the hearing aid by testing whether the user can hear test sounds at various thresholds to derive audiometric data. The audiometric data is used to determine the gain required according to formulae defined in standards such as the National Acoustics Laboratory standard. Further details of this standard can be found in "The National Acoustic Laboratories (NAL) new procedure for selecting the gain and frequency response of a hearing aid" by Bryne D and Dillon H. in Ear and Hearing 1986;7:257-.265.

[0005] Typically the test sounds are pure tones at frequencies varying in the range 250Hz to 8kHz. The user is requested to indicated at which amplitude the test sound becomes just barely audible. The audiologist notes the result data and adjusts the gain of the hearing aid manually or uses a control signal to adjust the gain of the hearing aid.

[0006] As an example of prior art arrangements of analogue or digital hearing aids, the testing and adjustment thereof, then please refer to US 6118877 A by AudioLogic Inc and dated 12th September 2000.

[0007] Over time, the hearing dysfunction of the hearing aid user varies for various reasons. Previously, it has been necessary to revisit the audiologist to refit the hearing aid. Such repeat visits are not only time consuming but also costly. Whilst awaiting refitting of the hearing aid, the users ability to hear properly may be severely impaired. This situation is particularly acute in areas of the world where access to an audiologist is very difficult.

[0008] An aim of the present invention is therefore to overcome this disadvantage. Accordingly, the present invention provides an IC chip for a hearing aid comprising:

control means (10) for receiving audio signals, test input data and test sound input and for activating test sounds;
a hearing rehabilitator (8) coupled to said control means to receive gain calibration signals for optimally adjusting said audio signals;
a first and second counter, each coupled to said control means for counting the test sounds to collate audiometric data;
a store coupled to the first and second counters and the control means for storing audiometric data; and
arithmetic means coupled to the control means and the store for deriving from the audiometric data the gain calibration to optimise the hearing aid, and characterised in that said control means includes means for limiting the maximum change in gain from that previously derived.

[0009] The present invention also provides a hearing aid which includes a hearing rehabilitator (8), said hearing aid comprising:

a microphone (2) for receiving audio signals;
an IC chip (4) coupled to the microphone and to said hearing rehabilitator; and
a receiver (6) coupled to the IC chip for outputting optimum audio signals;
whereby said IC chip includes means (10) for activating test sounds and for receiving audiometric data according to a users ability to hear said test sounds to calculate and adjust the gain calibration for optimising the hearing aid for the user, and in that said means (10) includes means for limiting the maximum change in gain from that previously derived.

[0010] Finally, the present invention also provide a system of adjusting a hearing aid including a hearing aid as defined above and input means, said system comprising:

activating the test sounds using the input means;
providing audiometric data using said input means; and
adjusting said gain calibration thereby enabling said user to adjust independently the hearing aid.

[0011] Advantageously, the present invention may be used by users not just with hearing dysfunction. Today, there is a large range of mobile audio equipment such as cassette players, radios, CD players, DAT players, mobile telephones and telephone receivers which all include earphones or headsets. The present invention may also be used in conjunction with such equipment and obviate any earphones or headsets if the user is wearing a hearing aid according to the present invention.

[0012] Embodiments of the present invention will now be described with reference to the following drawings, of which:

Figure 1 is a block diagram of a hearing aid and system according to the present invention;
Figure 2 is a block diagram illustrating testing stages of the hearing aid; and
Figure 3 is a schematic diagram of an IC suitable for use in a hearing aid.

[0013] The hearing aid according to the present invention as shown in Figure 1 includes a microphone 2 for receiving sounds, processing means 4 coupled to the microphone and a receiver 6 coupled to the processing means for outputting sounds adjusted for the users hearing dysfunction. The processing means includes a hearing rehabilitator 8 which adjusts the gain of the frequencies at which the user has hearing dysfunction. The processing means also includes a control 10 which controls the activation of test sounds and calculates the calibration of the hearing rehabilitator.

[0014] The hearing aid, when worn by a user receives sounds using the microphone which is passed to the hearing rehabilitator and the sounds are adjusted according to the users hearing dysfunction and then passed to the receiver to be output.

[0015] If the hearing aid is to be tested, then a user activates an input means 12 to initiate and proceed with the testing procedure. The input means acts by remotely emitting infrared signals and comprises a switch 14 for outputting an initiating signal and a detection means 16 for outputting detecting signals. When an initiating signal is output, the control means 10 activates the test sounds. The test sounds are produced by a test sound activation means 18 which may be a test tone generator or a memory containing test sounds or an input jack for connection to an external test tone generator (not shown). The test sound activation means runs through a predetermined set of test sounds and the user indicates whether the test sounds can be detected by way of the detection means 16.

[0016] In particular, as shown in Figure 2, the hearing test is first initiated. A first frequency is selected and a test sound at a first amplitude is output. The user indicates whether the test sound at that frequency and amplitude can be detected using the detection means. If the user did not detect the test sound, then the amplitude is raised until the user can detect the test sound at that frequency and amplitude to determine the respective threshold. The test sequence continues until all of the thresholds are established from the frequency and amplitude of the test sounds.

[0017] The predetermined set of test sounds are chosen in accordance with the standard formula used. The control means 10 monitors the test sequence by receiving data regarding the output of the set of test sounds and receiving the output from the detection means 16 to establish all of the thresholds in order to derive the audiometric data. The audiometric data is processed to derive the gain characteristics required of the particular user. The control means sends the gain characteristics required to the hearing rehabilitator to set the required gain characteristics for the user.

[0018] The control means also contains software to determine the maximum gain which may be set in order to protect the user. The control means also contains software to determine the maximum change in gain from the previous gain set, again to protect the user. Finally, the control means contains software which enables the test procedure to be interrupted or software which determines whether there has been no response during the test procedure for a certain period of time and interrupts the test procedure and maintains the gain currently set, again to protect the user.

[0019] The hearing aid of the present invention enables the user to adjust the hearing aid so as to provide optimum compensation whenever initiated by the user using the system for adjusting the hearing aid as discussed above. Accordingly, a user need not visit an audiologist in order to adjust the hearing aid. It is intended that the ability to re-calibrate the gain of the hearing aid is a separate function to any other form of processing that the aid may perform.

[0020] The hearing aid of the present invention is preferably a digital hearing aid. Thus, an analogue to digital converter will be required between the microphone and the processing means and a digital to analogue converter will be required between the processing means and the receiver. It is also preferable for the processing means to be provided on an IC chip as shown in Figure 3.

[0021] Figure 3 demonstrates an IC chip 4 receiving sound input, test data input and test sound input. All of this input is provided to the control means 10. Control means 10 is also coupled to a hearing rehabilitator 8. The hearing rehabilitator 8 includes software for filtering, amplifying and dynamic range compressing the sound input according to calibration signals provided by the control means. The calibration signals have been previously determined or calculated to provide optimum adjustment for the user of the hearing aid.

[0022] The hearing aid calculates the control signals using an arithmetic means 20, a register store 22 and counters 24 and 26, each of which are coupled to the control means 10. When testing commences, the control means detects the initiation signal and controls the output of test sounds. The counters 24 and 26 count the amplitudes and the test frequencies to determine the respective thresholds at which the test sounds can be heard by the user under the control of the control means 10. The thresholds are stored in the register store 22. When the testing procedure is complete, then the arithmetic means 20 receives the threshold data and calculates the calibration signals and these are provided to the control means 10. If the calibration signals are within the safety ranges as discussed above, then the calibration signals are provided to the rehabilitator 8.

[0023] The present invention may also be used in connection with audio mobile equipment such as cassette

players, radios, CD players, DAT players, mobile telephones and telephone receivers which all include earphones or headsets. The audio mobile equipment could be provided with input means 12 which is capable of providing signals to the control means 10 to increase the gain characteristics for all frequencies or selected frequencies depending upon whether the user has any hearing dysfunction. In addition, the test sound activation means if provided with an input jack could be used to connect to the mobile equipment. When the hearing aid is used in connection with any audio mobile equipment, then the control means would need additional or alternative software to control the hearing aid accordingly.

[0024] The aforegoing description has been given by way of example only and it will be appreciated that modifications may be made without departing from the scope of the present invention. For example, the input means (12) need not operate by infra-red but could operate in other ways such as radio wave communication. Alternatively, the input means could be integrated into the hearing aid.

Claims

1. An IC chip for a hearing aid comprising:

   control means (10) for receiving audio signals, test input data and test sound input and for activating test sounds;
   a hearing rehabilitator (8) coupled to said control means to receive gain calibration signals for optimally adjusting said audio signals;
   a first and second counter, each coupled to said control means for counting the test sounds to collate audiometric data;
   a store coupled to the first and second counters and the control means for storing audiometric data; and
   arithmetic means coupled to the control means and the store for deriving from the audiometric data the gain calibration to optimise the hearing aid, and **characterised in that** said control means includes means for limiting the maximum change in gain from that previously derived.

2. An IC chip as claimed in claim 1, in which said control means includes means for limiting the maximum gain calibration.

3. An IC chip as claimed in claim 1 or claim 2, in which said control means includes means for interrupting the test sound input.

4. A hearing aid which includes a hearing rehabilitator (8), said hearing aid comprising:

   a microphone (2) for receiving audio signals;
   an IC chip (4) coupled to the microphone and to said hearing rehabilitator; and
   a receiver (6) coupled to the IC chip for outputting optimum audio signals;
   whereby said IC chip includes means (10) for activating test sounds and for receiving audiometric data according to a users ability to hear said test sounds to calculate and adjust the gain calibration for optimising the hearing aid for the user, and in that said means (10) includes means for limiting the maximum change in gain from that previously derived.

5. A hearing aid as claimed in claim 4, further comprising input means (12) for initiating said test sounds and for providing data according to whether the user can hear the test sounds.

6. A hearing aid as claimed in claim 5, in which said input means communicates with said control means via wireless communication.

7. A hearing aid as claimed in any one of claims 4, 5 or 6, further comprising an analogue to digital converter coupled to said microphone and a digital to analogue converter coupled to said receiver.

8. A hearing aid as claimed in any one of claims 4 to 7, in which said IC chip is as claimed in any one of claims 1 to 3.

9. A system of adjusting a hearing aid, including a hearing aid as claimed either claim 5 or 6, said system comprising:

   activating the test sounds using the input means;
   providing audiometric data using said input means; and
   adjusting said gain calibration thereby enabling said user to adjust independently the hearing aid.

Fig.1.

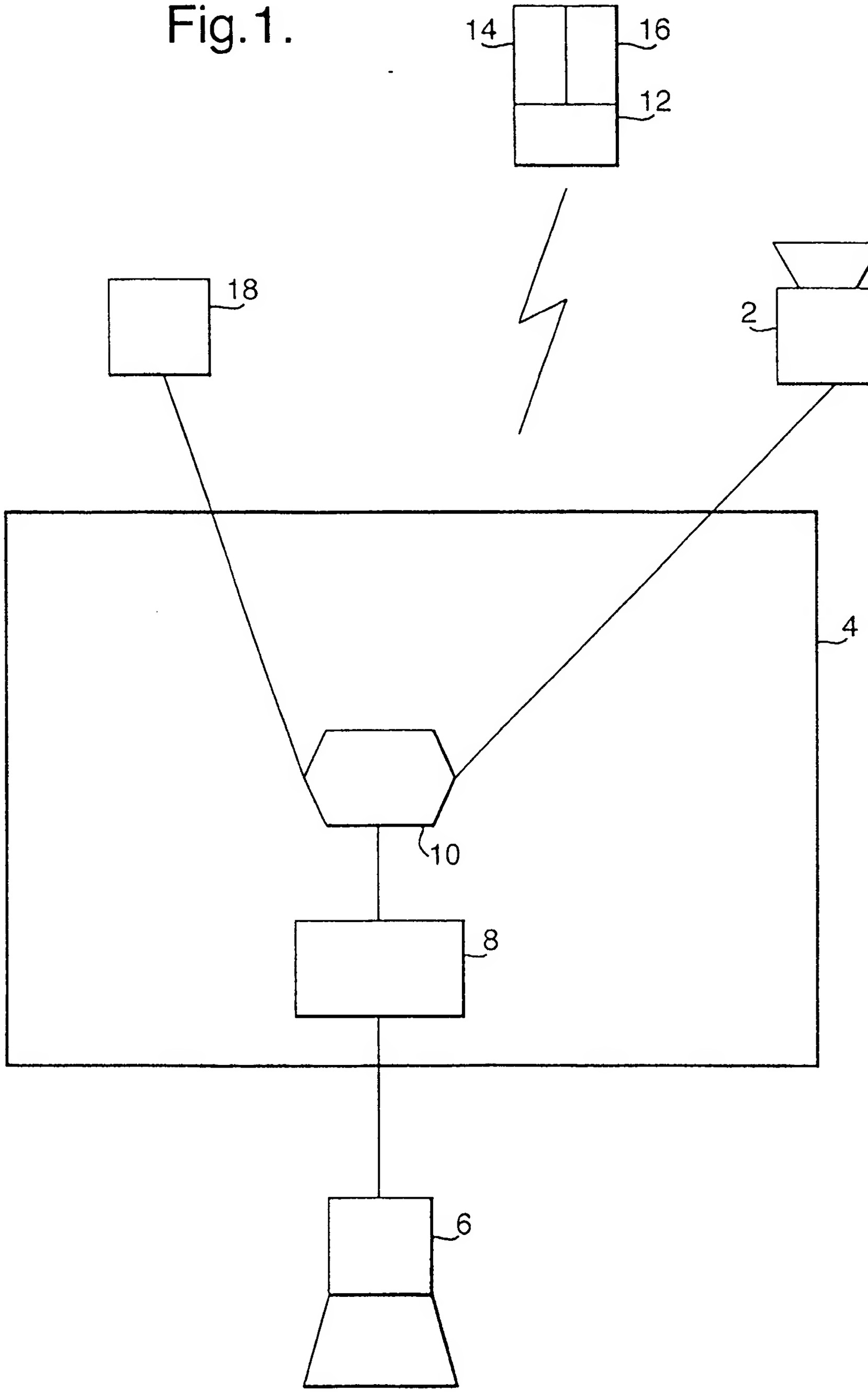


Fig.2.

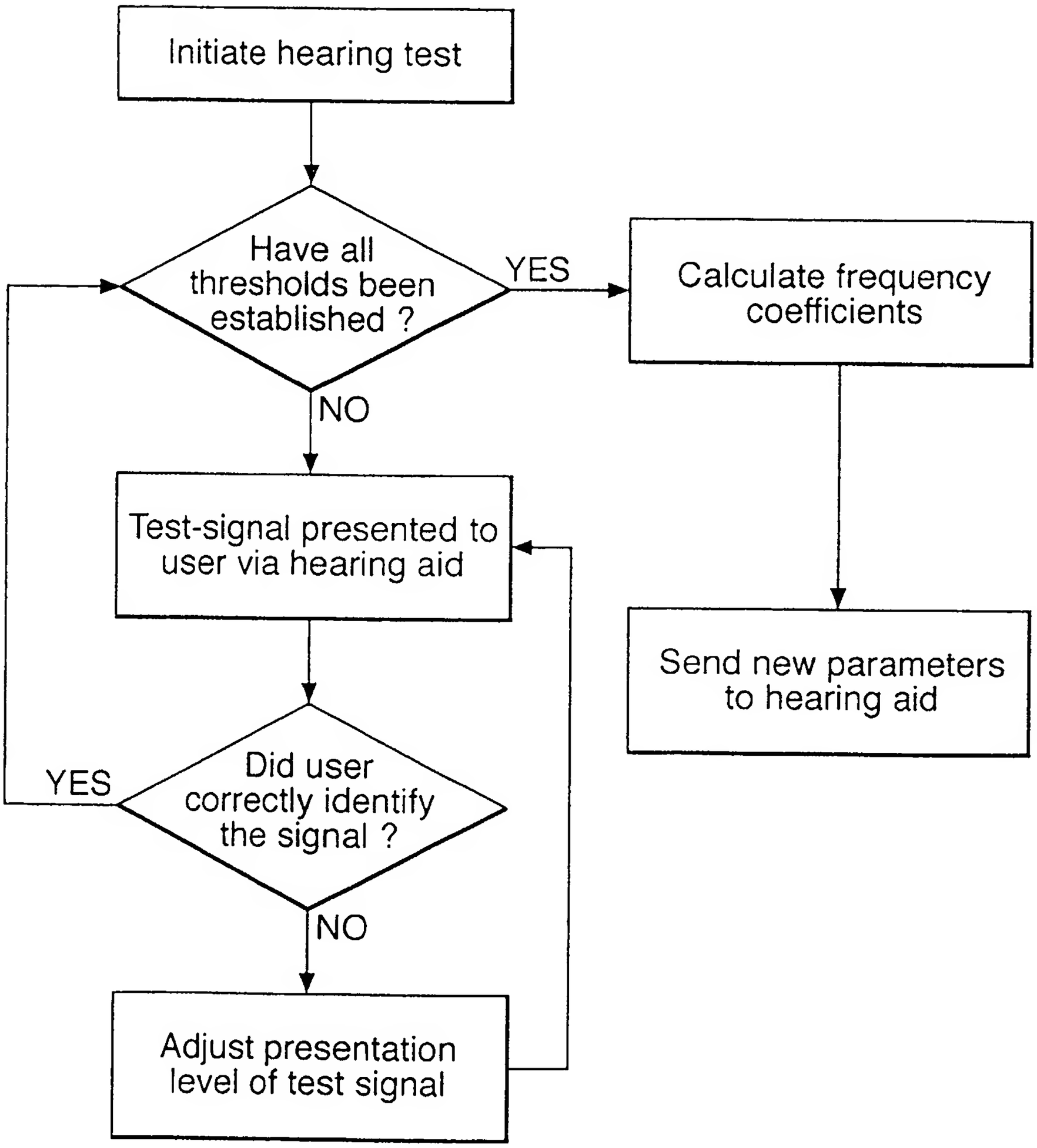

Initiate hearing test
Have all thresholds been established ?
YES
NO
Calculate frequency coefficients
Send new parameters to hearing aid
Test-signal presented to user via hearing aid
Did user correctly identify the signal ?
YES
NO
Adjust presentation level of test signal

Fig.3.